Adult Chinook Escapement Assessment conducted on the Nanaimo River During 2009

C.P. Lam and E.W. Carter

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
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by

C.P. Lam and E.W. Carter

Fisheries and Oceans Canada

Science Branch, Pacific Region

Pacific Biological Station

Nanaimo, British Columbia

V9T 6N7

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In 2009, Fisheries and Oceans Canada in co-operation with Snuneymuxw First Nation and Nanaimo River Hatchery continued an escapement study of Chinook salmon (*Oncorhynchus tshawytscha*) in the Nanaimo River. Areas of concentration for this study included:

i) Generating an area-under-the-curve population estimate by conducting swim surveys in the lower Nanaimo River for fall run chinook;
ii) Enumerating summer run Chinook by aerial and snorkel surveys; and
iii) Collecting biological and coded wire tag (CWT) data.

The return of fall run adult Chinook to the Nanaimo River was estimated to be 1,470 of which 151 were collected for broodstock purposes leaving 1,319 to spawn naturally. Snorkel survey estimated the naturally spawning population of the summer stock to be 148 fish plus 163 fish collected for hatchery broodstock for a total return of 311 fish.

The return of all adult Chinook, including First Nation catch, naturally spawning fall, summer and spring run and hatchery removals, to the Nanaimo River system in 2009 was estimated to be 2,230 fish.

RÉSUMÉ

Lam, C.P., and Carter, E.W. 2010. Adult Chinook escapement assessment conducted on the Nanaimo River during 2009. Can. Manuscr. Rep. Fish. Aquat. Sci.: 2940: vii + 37 p.

En 2009, Pêches et Océans Canada, en collaboration avec la Première nation Snuneymuxw et l'écloserie de la rivière Nanaimo, a poursuivi sa campagne de recensement des échappées de saumon quinnat (*Oncorhynchus tshawytscha*) dans la rivière Nanaimo. Cette étude portait principalement sur ce qui suit :

- iv) Établissement de l'effectif en fonction de « l'aire sous la courbe » par la conduite de sondages à la nage portant sur la remonte automnale de quinnat dans le cours inférieur de la rivière Nanaimo;
- v) Dénombrement de la remonte estivale de quinnats par la conduite de sondages aériens et de sondages en plongée libre;
- vi) Collecte d'échantillons biologiques et de données à partir des marquages par fil codé (CWT).

L'effectif de remonte automnale du quinnat dans la rivière Nanaimo se chiffrerait à 1 470 individus, dont 151 ont été prélevés aux fins du cheptel de culture, pour 1 319 échappées de fraye naturelle. La campagne de sondage en plongée libre a permis d'établir que la remonte estivale avait produit 148 individus pour la fraye naturelle contre 163 prélèvements pour le cheptel de culture, pour un effectif de remonte total de 311 poissons.

L'effectif de remonte total de quinnats adultes dans le bassin de la Nanaimo pour l'année 2009, comprenant les pêcheries autochtones, les remontes automnale, estivale et printanière vers les écloseries naturelles et les prélèvements destinés au cheptel d'élevage, a été estimé à 2 230 poissons.

INTRODUCTION

Since 1988, Fisheries & Oceans Canada (DFO) has focused considerable interest on the status of Chinook salmon (*Oncorhynchus tshawytscha*) stocks in the lower Strait of Georgia. The Nanaimo River, Cowichan River and the Squamish River, were chosen to represent the lower Strait of Georgia as exploitation and escapement indicator rivers (PSC 1990). Escapement information is used to evaluate rebuilding strategies and harvest management policies for lower Strait of Georgia Chinook (Farlinger et al. 1990). Since then, due to logistical reasons, the Squamish River system was dropped as an indicator. The Nanaimo River system was also discontinued as an exploitation rate indicator in 2002 and the enumeration fence was discontinued the following season in 2003. However, the Nanaimo River system remains an important escapement indicator for lower Strait of Georgia Chinook with the unique distinction of monitoring one fall and two spring runs.

In 2004 the Cowichan River hatchery lost all its brood stock due to heavy snowfall resulting in a power and pump failure. Therefore no fry were available to be coded-wire tagged from Cowichan. As an alternative, Nanaimo River fry were marked and the river became the surrogate indicator river for that brood year. Over the past five years, the system has been comprehensively assessed using alternative escapement methods (i.e. Area under the Curve and Petersen mark-recapture) to estimate the Chinook population returning to the watershed. In 2009, DFO, Science Branch, in conjunction with Snuneymuxw First Nation and the Nanaimo River Hatchery continued to operate carcass mark-recapture and swim survey programs to collect Chinook escapement and coded-wire tag information.

Nanaimo River Chinook exhibit a variety of life history strategies, with at least three genetically distinct runs produced (Carl and Healey 1984). Unique to only a few systems on the East coast of Vancouver Island, there are two distinct spring Chinook stocks and one fall run stock returning to the Nanaimo River (Figure 1).

The two spring run stocks enter the river between March and August and hold in First Lake, Second Lake or deep canyon pools until they spawn during late summer/early fall (Brahniuk et al. 1993, Nagtegaal and Carter 2000). The upper Nanaimo River spring Chinook stock spawns upstream of Second Lake to Sadie Creek at the outlet of Fourth Lake, in October (Hardie 2002). The majority of fry are stream-type which rear for up to one year before out-migrating to the estuary (Healey 1980, Nagtegaal and Carter 2000).

The First Lake summer run spawns within the first 1.6 kilometers downstream of the First Lake outlet to the Wolf Creek junction pool (Healey and Jordan 1982, Hardie 2002). The peak of spawning is typically during the first two weeks of October (Nagtegaal and Carter 2000, Brahniuk et al., 1993). Chinook fry produced from the late spring run are mostly ocean-type and rear for 90 days in freshwater before migrating to sea. Stream-type fry will be more vulnerable to changes in freshwater productivity and habitat conditions than ocean-type fry that out-migrate upon emergence. Once in the estuary, First Lake fry exhibit greater agonistic behaviour than fry produced by the lower Nanaimo stocks due to their longer period of territorial stream residence prior to migration into the estuary (Taylor 1990).

The larger fall Chinook stock enters the Nanaimo River during August/September and a large proportion of the run spawns in the lower river downstream of the Borehole/lower canyon area down to the Cedar Road Bridge (Healey and Jordan 1982, Hardie 2002). Some of the fall Chinook run ascend the falls to spawn in the upper river downstream of First Lake. The majority

(99%) of fry incubated in the lower river exhibit ocean-type life history strategy and out-migrate to sea upon emergence to rear in the estuary (Healey and Jordan 1982).

Hatchery production of Chinook on the Nanaimo River began in 1979 (Cross et al. 1991). In that first year, eggs were incubated at the Pacific Biological Station and later released into the river. The first year of production at the hatchery facility was 1980 (1979 brood) when 100,000 fall run Chinook fry were released. Over the years fry production has increased, and in 2009, a total of 418,068 fall run Chinook fry and 232,496 summer run Chinook fry were released into the Nanaimo River and First Lake, respectively. There was no hatchery enhancement for the Nanaimo River spring run Chinook stock in 2009.

Coded-wire tagging of Chinook began in 1979 and by 2004, 75.6% of fall run Chinook fry carried coded-wire tags (CWT). The 2004 brood at Cowichan River Hatchery perished as a result of a power outage and no fry were available for coded-wire tagging, therefore it was decided by DFO to tag the Nanaimo River fish as a surrogate for that brood year. No coded-wire tagged Chinook fry have been released since 2005.

In addition to Chinook, the Nanaimo River also supports stocks of coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), steelhead trout (*O. mykiss*), cutthroat trout (*O. clarki*), and Dolly Varden char (*Salvelinus malma*).

In consultation with various user groups, the B.C. Ministry of Environment, Lands and Parks initiated a Nanaimo River Water Management Plan in June of 1989. The primary goal of the plan was to improve salmon escapement by increasing flows during typically low water levels in the fall while at the same time maintaining adequate flows to satisfy industrial and domestic water use (Ministry of Environment, Lands and Parks 1993).

The objectives of the 2009 escapement study included:

1. Providing fall run, First Lake summer run, and spring run Chinook salmon estimates for the Nanaimo River watershed,
2. Estimating the Snuneymuxw First Nation food fishery catch,
3. Recording hatchery broodstock removals of fall and summer run Chinook,
4. Implementing a carcass mark-recapture study for both fall run and First Lake summer run Chinook,
5. Collecting biological data, recovering CWT's, and
6. Generating an area-under-the-curve (AUC) estimate through swim surveys in the lower Nanaimo River.

This report presents the results of the escapement study completed during 2009.

METHODS

Two methods were employed to estimate chinook spawning escapement in the Nanaimo River for 2009. These included carcass mark-recapture techniques and swim surveys. The AUC technique was used to generate a Chinook population estimate for fall run stock only. Biological data including length, sex, scales, presence/absence of an adipose fin, otoliths and coded-wire tagged heads were collected from carcasses during mark-recapture and broodstock collection programs. Aerial surveys to assess Chinook numbers were not conducted, in 2009. An attempt to collaborate with the chum escapement flights was unsuccessful as these flights were too late in the season for Chinook.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

Escapement estimates were generated from mark-recapture data using the pooled Petersen model (Chapman modification; Ricker 1975) for fall run adult and jack Chinook. The mark-recapture also provided information on length frequencies, age composition, and sex composition. CWT data were also collected for use in calculating enhanced (hatchery) contribution in the Nanaimo River watershed.

The carcass mark-recapture estimate is based on recoveries of Chinook carcasses tagged on the Nanaimo River spawning grounds. This method of population estimation is implemented for several reasons. First, the handling and tagging of live Chinook causes stress and could delay the upstream migration. Second, the carcasses provide the primary source of CWT recoveries and biological information. For these reasons the tagging of Chinook carcasses is preferred because it provides an independent estimate of population while minimizing the physical contact to spawning Chinook salmon.

The carcass mark-recapture operation involved a crew of three people in an inflatable boat searching the river daily or whenever the weather permitted for spawned-out Chinook carcasses. Each carcass was tagged with a numbered Ketchum[1] aluminum sheep ear tag on the left operculum and released into the river. Fish were also hole-punched in the left operculum to indicate they had been tagged in the event the aluminum tag was lost. For all recaptures, tag number and location were recorded. Once recaptured, the carcass was removed from the river to avoid multiple recaptures.

Biological information such as post orbital-hypural (POH) length, sex, capture location, and the presence or absence of an adipose fin were recorded. If the adipose fin was missing the head was catalogued and taken for CWT analysis at the laboratory. Five scale samples were taken from the preferred area to be analyzed for age composition (Shaw 1994). Otoliths were also collected from Chinook for examination for thermal marking to assess the possibility of strays from large scale hatcheries from the US and Canada. Chinook fry released from these hatcheries have been exposed to varying temperatures and as a result, have a distinct banding pattern on their otoliths (Hoyseth and Hargreaves 1995).

Recovery effort was concentrated on the lower portion of the Nanaimo River sampling fall run Chinook, which generally spawn between the Island Highway Bridge and the Cedar Bridge. One day of sampling was conducted on the upper portion of the Nanaimo River targeting summer run Chinook, which spawn in a two-kilometer stretch of river between the

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[1] Ketchum Manufacturing Ltd., Ottawa, Canada

outlet of First Lake and the Wolf Creek confluence. Fish in this upper section were biologically sampled only and no Petersen mark-recapture was attempted on this stock. Therefore, the summer run estimate is based on snorkel survey data only.

Biological information similar to that recorded for the carcass mark-recapture was provided by Nanaimo River Hatchery staff from broodstock collection from both fall run Chinook and summer run Chinook.

Mark-recapture estimates were calculated using a pooled Petersen estimator. Since the true population size was unknown, a direct measure of the accuracy of the estimates was not possible. However, an assessment of the underlying assumptions of equal probability of capture, simple random recovery sampling, and complete mixing can usually be made by testing recovery and application samples for temporal, sex, and size related biases (Schubert 2000). To carry out most of the bias assessments, different gear types must be utilized for capturing the tag application and the recovery samples. In the current study, the spawning ground carcass mark-recapture was used to attain both samples thus limiting the ability to assess sample bias.

Finding sampling bias usually results in the use of a stratified estimator; however, Schubert (2000) compared the performance of several mark-recapture population estimators for a sockeye salmon population of known abundance and concluded that the pooled Petersen estimator was less biased and preferred over stratified estimators. In that study, the Schaeffer estimator would not improve accuracy and it was recommended that the method be abandoned for use in population estimation. Also, it was determined that while the maximum likelihood Darroch estimator could potentially improve accuracy, there was no obvious way of selecting between accurate and highly biased estimates. Parken and Atagi (2000) found that pooled and stratified estimators of Nass River summer steelhead produced similar escapement estimates; however the pooled estimator was more precise, and had less statistical bias than the stratified estimator. These findings indicate the robust nature of the pooled Petersen estimator and suggest that its use to determine population abundance from mark-recapture data is generally appropriate under a wide range of circumstances.

SWIM SURVEYS

Nanaimo River Hatchery staff conducted and coordinated swim surveys to provide an independent estimate of spawning Chinook and to assess spawning distribution throughout selected portions of the lower Nanaimo River. Swim surveys were carried out using three or four swimmers who stay abreast of each other while moving downstream. Swimmers combined their individual counts, which were recorded at pre-defined locations in the river (Figure 2).

Eight swim surveys conducted in lower portions of the Nanaimo River watershed in 2009 between 31 August and 19 October were used to calculate an AUC estimate for fall run chinook (English et al. 1992; Irvine et al. 1993). In this portion of the river, swim counts were combined into four segments.

FIRST NATIONS FOOD FISHERY

In 2009, Fisheries Guardians from Snuneymuxw First Nation (SFN) and staff from DFO Stock Assessment worked to establish a reliable method of collecting data to calculate catch estimates. Guardians conducted interviews with SFN members fishing on the river and made regular effort counts. Data collected during interviews included the number of hours an individual fished and what they caught and released providing a catch rate (number of fish per hour). Effort counts provided the number of active fishers on a given day and throughout the period. Multiplying catch rate by effort produces an estimate of total catch. This methodology is used in the Strait of Georgia Creel Survey to estimate catch in the recreational fishery. From SFN Guardians' observations, and post season interviews with fishers, a total catch estimate was determined.

WATER MANAGEMENT PLAN

Low flows and water levels likely result in delayed fish movement and higher water temperatures, which may potentially increase levels of disease and parasites. This is particularly true for the parasite Ich or White Spot Disease (*ichthyophthirius Multifiliis*), which matures more rapidly with higher temperature (Ministry of Environment, Lands and Parks 1993). During particularly low water levels, the river flow can be increased with a controlled water release.

Two man-made reservoirs in the Nanaimo River system have been utilized to increase flows during periods of low flow between late summer and early fall. Prior to 1989, water releases were conducted based on an informal arrangement between local DFO Conservation and Protection Officers and Harmac Pacific. DFO Officers would request a water release when, in their opinion, fish holding in the lower river became threatened due to low water. These requests would be granted by Harmac depending upon the availability of water in reserve.

With the increase in population in the Nanaimo area and in an effort to satisfy domestic, industrial, agricultural, fishery, wildlife, and recreational needs, a Nanaimo River Water Management Plan (NRWMP) was initiated by the B.C. Ministry of Environment (BCMOE) in June of 1989. A team comprised of members from the BCMOE, Greater Nanaimo Water District, Pope and Talbot (formerly MacMillan Bloedel Limited), Snuneymuxw First Nation, and DFO negotiated a water flow management plan (Ministry of Environment, Lands and Parks 1993). The primary water management goal has been to enhance flows to meet fisheries requirements while maintaining flows to satisfy industrial and municipal needs. This is particularly important during periods of lowest flow (September and October) and in the ten-kilometer section of river below the Harmac Pulp Operations water intake area. Increases in the fall water releases from the reservoirs since 1989 have encouraged spawning migration

The Nanaimo River Water Management Plan also incorporates the ramping (a gradual increase and/or decrease) of water levels to minimize effects of sudden changes in river dynamics. Possible effects include the stranding of fish, alteration of river hydrology, and erosion of riverbanks. The recommended minimum duration of a water release is 48 hours, with the optimum release time being three to four days. The recommended minimum discharge for a water release is 14.87 m^3/s (525 ft^3/s), to be released from Fourth Lake (Hop Wo et al. 2005).

RESULTS

CARCASS MARK-RECAPTURE

In 2009, the carcass mark-recapture program was completed on the lower Nanaimo River for seven days during the month in October and November. Only one day was dedicated to the upper Nanaimo River for mark-recapture. Conditions during the mark-recapture in the two months might have been difficult due to the high water flow near the end of October. Daily Nanaimo River discharge for the duration of the carcass mark-recapture is presented in Table 1 and Figure 3.

Potential Biases

The assessment of sampling selectivity had several potential biases in the carcass mark-recapture study. These potential biases would be temporal, fish sex and size. These biases have been determined in previous years' reports but this year is an exception. The temporal and size bias could not be calculated as there were insufficient samples collected. Calculations by gender were made based on the total population of fish. There was a total of seven recaptured: three females and four males. In order for the Chi-square test to function, sample size needs to have a population size of five or greater.

Overall, the total population of males and females in the marking period had a significant deviation. The fall Chinook sex ratio was not 50% during the marking period. (Chi-Square = 6.25, degrees of freedom = 1, $p < 0.01$) Calculations were based on the carcass mark-recapture project, not including jacks or coded-wire tagged Chinook.

Fall Run Assessment

The fall run Nanaimo River carcass mark-recapture commenced on 19 October 2009, consisted of seven sampling days, and was completed 30 October 2009 (Table 2). Male Chinook observed on the carcass mark-recapture were provisionally designated as an adult (Age 4_1+) or jack (Age 3_1) based on size (450 mm). The ability to divide males based on age was utilized once the scales were read.

During the sampling period, 27 male, 33 female, and seven jack adult Chinook were tagged and released in the lower Nanaimo River (Table 2). Tagged carcass recapture rates included three (11.1%) males, three (9.1%) females, and one (14.3%) jack. Given the low number of recoveries, the Petersen mark-recapture calculations could not be used.

Summer Run Assessment

Due to limited crew availability there was only one day when biological sample data were collected for summer run Chinook. The upper river was sampled on 6 November 2009 with five males, five females and one jack collected.

SWIM SURVEYS

In 2009, a total of eight swim surveys were conducted in the lower portion of the Nanaimo River to determine abundance and distribution of fall run Chinook (Table 3). Swims were conducted in the upper Nanaimo River to determine summer and spring run stock abundance and distribution. Swims targeting fall run Chinook began on 31 August and ended on 19 October in the lower river. Most of these swims started at the Island Highway Bridge pool and ended at Raines Rock pool within tidal influence.

The swim surveys conducted in these lower portions of the Nanaimo River between 31 August and 19 October were used to calculate an AUC estimate for fall run Chinook. The river was divided into four segments which contained multiple adjacent pools and riffle sections, specifically; Segment 1, Bridge Pool to Alder Run; Segment 2, Haslam Creek Junction to House Pool; Segment 3, Maffeo Side Channel to Fire Hall; and Section 4, Barn Hole to Raines Pool (Figure 2). Daily Nanaimo River discharge during the course of the swim surveys is presented in Figure 3.

Due to high numbers of chum and low numbers of Chinook downstream of the Fire Hall pool, the final lower river swim was shorter and only included the length of river between the Island Highway Bridge pool and the Fire Hall pool.

There was one swim on 19 October from First Lake to Wolf Creek estimating 148 adults, 36 Jacks and 12 dead summer run Chinook.

AREA UNDER THE CURVE

The metrics required in calculating an AUC estimate include survey life and observer efficiency (OE). A survey life statistic is generated through a tagging process. Observer efficiency accounts for fish missed by observers and is based on observation conditions such as water level, turbidity, river complexity and weather conditions.

In 2009, fish were not holding in large numbers in the typically accessed pools and consequently too few fish were available for capture and tagging for a new survey life statistic, though water conditions were good for observation and fish distribution. For all AUC calculations, the 2006 survey life of 11.5 days was used (Graf and Carter, 2007).

Observer efficiency varied slightly between swims, but remained high throughout the survey period as water levels stayed low to moderate and visibility was good in generally clear water. Observer efficiency ranged from 60% - 91% (Table 3). Species identification and number of habitats surveyed was taken into account when calculating the AUC estimate.

The calculated AUC estimate for fall run adult Nanaimo River Chinook is 1,470 fish. An AUC estimate was also generated for fall run jack Chinook within the lower Nanaimo River using the same survey life (11.5 days) and observer efficiencies as adult Chinook. This methodology yielded an estimate of 630 jack Chinook. Please note both of these AUC estimates are for total returns and have not been adjusted for broodstock removals. Swim survey counts with expanded estimates are presented in Table 3.

No AUC estimate was calculated for the summer run Chinook as there were insufficient swim data collected targeting this group.

FIRST NATION FOOD FISHERY

An in-river rod and gillnet fishery for Chinook takes place in September and October to provide Food, Social, and Ceremonial fish for the SFN. This fishery is held in a one-kilometre area downstream of the Cedar Bridge and monitored by the SFN Fisheries Guardians. In 2009, the estimated Chinook catch was 449 adults. There were no biological samples collected from Chinook or Coho caught in this fishery in 2009.

BROODSTOCK REMOVALS

From 8 October to 19 October, Nanaimo River Hatchery's field records show 72 male, 79 female, and 50 jack fall run Chinook were collected for broodstock purposes from lower portions of the Nanaimo River (Table 4). From 2 October through to 7 October, 94 male, 69 female and two jack summer run broodstock Chinook were collected from First Lake.

BIOLOGICAL DATA

During the fall run spawning ground carcass mark-recapture, 22 male, 42 female, and six jack Chinook carcasses were sampled and measured for post orbital-hypural (POH) length (Table 2). The lengths of adult male Chinook ranged from 480 mm to 710 mm and averaged 612 mm. Adult females ranged from 580 mm to 790 mm and averaged 689 mm. Jack Chinook ranged in length from 380 mm to 450 mm and averaged 418 mm (Table 5A).

The lower Nanaimo River mark and recapture program for fall run Chinook Age analysis (Gilbert Rich Age) of male Chinook revealed that 7.1% were 2_1, 78.6% were 3_1, and 14.3% were 4_1 (Table 6A). Analysis of female Chinook scales indicated that 3.4% were 2_1, 34.5% were 3_1, and 62.1% were 4_1.

During the summer run spawning ground carcass biological sampling, five male, five female, and one jack summer run Chinook carcasses were sampled and measured for POH length. The lengths of adult male Chinook ranged from 490 mm to 680 mm and averaged 590 mm. Females ranged from 588 mm to 716 mm and averaged 666 mm, and the one jack was 427 mm (Table 5B).

Age information provided from scale data was used to determine whether fish were jacks or adults except fish whose age could not be determined fully. There were 22 fish where age could not be determined. Of these 22 fish, 13 were female, eight were male and there was one jack. The 43 adult fish with complete ages had Gilbert Rich age values of 2_1, 3_1 or 4_1 (Tables 6A and 6B).

When comparing mean lengths of female fall run Chinook recovered from the spawning grounds to female hatchery broodstock samples, it was found that the broodstock fish were significantly smaller than fish from the carcass mark-recapture study (Student's t-test: $t = -3.01$; degrees of freedom = 107; $p = 0.003$). Unfortunately jack analysis could not be completed as there were too few fish to meet the minimum sample size for statistical analysis. The T-test comparisons between mean length of male Chinook sampled at the hatchery and those recovered in the mark-recapture program revealed a large significance (Student t-test: $t = -3.02$; degrees of freedom = 78; $p = 0.003$)

Comparisons between mean length of female summer run Chinook recovered on the spawning grounds and Chinook sampled from hatchery broodstock yielded no significant difference (Student t-test $t = 0.213$; degrees of freedom = 64; $p = 0.833$). Similarly, lengths of summer run male fish sampled at the hatchery were not significantly different in size from fish sampled on spawning grounds (Student t-test: $t = -0.165$; degrees of freedom = 30; $p = 0.870$).

There was a high significant difference found between the mean lengths of female and male fall run broodstock sampled at the Nanaimo River hatchery (Student's t-test: $t = 7.29$; degrees of freedom = 123; $p = 0.000$), with females being significantly larger. The mean lengths of female and male summer broodstock sample were similar to fall results (Student t-test: $t = 4.38$; degrees of freedom = 50; $p = 0.000$).

Age analysis of male and female Chinook in the upper Nanaimo River revealed that all were 3_1 (Table 6B). All summer run Chinook were found to be ocean-type fry, as all scales exhibited no over-wintering in freshwater. Of fish sampled during the carcass mark-recapture operations, there was insufficient data to conduct a test for significant differences between the mean lengths of fall and summer run male Chinook calculations made in a Student t-test .

A total of 58 adult male, 67 female, and 25 jack fall run Chinook were sampled from hatchery broodstock, measured for POH length, scale sampled and examined for adipose-clipped fins. Adult male Chinook ranged from 380 mm to 770 mm and averaged 553 mm. Female Chinook lengths ranged from 530 mm to 800 mm and averaged 650 mm, jack Chinook ranged from 360 mm to 480 mm and averaged 420 mm (Table 7).

Fall run Chinook taken for broodstock from the lower Nanaimo River were aged as follows: males – 25.7% 2_1, 65.7% 3_1, 8.6% 4_1; females – 43.8% 3_1, and 56.3% 4_1 (Table 8A). Age composition of summer run Chinook is as follows: males – 13.3% 2_1, 80.0% 3_1 and 6.7% 4_1, females – 8.3% 2_1, 75.0% 3_1 and 16.7% 4_1, (Table 8B). All summer run Chinook were found to be ocean-type as no scales exhibited over-wintering in freshwater.

During summer broodstock capture, the Nanaimo River Hatchery staff did not recover any Chinook with missing adipose fins. For a list of Nanaimo River Hatchery fry releases, brood years 1997 – 2007, see Table 9. For fry releases to the Chemainus River and Cowichan River Watershed, brood years 2002 – 2006, see Table 10.

During the fall run broodstock collection the Nanaimo River Hatchery group found one female Chinook missing an adipose fin, denoting a possible CWT (Table 10). This tagged Chinook was from the Chemainus Hatchery released in 2006 brood.

Otoliths were collected from 58 carcasses from the fall run (16 male, 36 female, six jack) and 11 from the spring run (five male, five female, one jack) Chinook. At this point otoliths have not been analysed for thermal marks.

WATER MANAGEMENT PLAN

In 2009, one scheduled water release occurred on 5 October to assist in migration of Chinook stocks into the Nanaimo River. Due to sufficient rainfall which kept river levels elevated for most of October and November, additional water releases were not required. Daily Nanaimo River discharge is presented in Table 1 and Figure 4.

POPULATION ESTIMATE

The estimated total return of Chinook to the Nanaimo River Watershed for summer and fall run stocks is 2,230 adults and 668 jacks. The number of naturally spawning fall run adult Chinook in the Nanaimo River during 2009 was determined by the AUC swim survey estimate (1,470 fish) minus the net fall run broodstock removals (151 fish). Following this methodology, the total number of adult fall run Chinook spawning in the Nanaimo River was estimated to be 1,319 fish (Table 11A). The total return of adult fall run Chinook to the Nanaimo River was determined to be the sum of the AUC swim survey estimate (1,470 fish), plus the First Nation fishery catch (449 fish), yielding 1,919 fish.

An AUC estimate for fall run jack Chinook (630 fish), minus broodstock removal (50 fish) had yielded 580 natural spawners. Hatchery broodstock are not used in the calculation because the capture method is much less random than deadpitch. The total return of fall run jack Chinook was determined to be the AUC estimate of 630 fish. No Petersen mark-recapture was performed in 2009 on summer run Chinook as sample size was insufficient for such an analysis. The total return for all jack Chinook to the Nanaimo River was estimated to be the total fall run jack Chinook yielding 668 fish (Table 11B).

DISCUSSION

CARCASS MARK-RECAPTURE

Variable water conditions existed through most of the mark-recapture program, which commenced on 19 October and ended on 3 November. Water levels averaged 39.5m^3/s during the survey period.

Low flows during the study period do not facilitate mixing of carcasses. If the carcasses do not properly mix they are easily recaptured later in the study resulting in a low Petersen estimate. Biases in data collection may explain the large difference in population estimates between the AUC and Petersen methods. Without proper mixing and closed containment of the population, it is easy for live or dead fish to enter and leave the sampling area biasing results. The carcass mark-recapture for 2009 had insufficient data to compare with previous years' results.

Fall Run Assessment

When comparing mark rates between hatchery samples to the fall run carcass mark-recapture program, a Chi-Square analysis is performed. In the 2009 data there were insufficient data collected during the carcass mark-recapture program to conduct the Chi-Square analysis on temporal, sex, or size between mark-recapture periods, but we were able to use the total period of the mark-recapture program. The analysis concluded that there was no significant difference between females and males in the mark and recapture rate.

As in previous years, temporal bias was calculated when comparing recovered and unrecovered tags to total tags applied. Over the four discrete periods it was determined that there was no significant temporal bias in adult males but in females and the pooled sexes there was a significant bias. These biases are not uncommon being an open site, fewer fish are available for tagging later in the study.

Water discharge can play an important role in the success of the mark-recapture program and with very large fluctuations in water discharge over the sample period, mixing may be variable and access can be difficult. Also, there can be problems with predators (bears) that may remove the tagged carcasses from the sample area, especially during the beginning of the study. After some time the bears will become satiated and remove fewer carcasses, biasing the results (D. Nagtegaal, DFO Stock Assessment Biologist, 5353 Club Road, Duncan, B.C., V9L 3X3. pers. comm.).

Summer Run Assessment

One swim survey occurred in 2009 in the upper Nanaimo River from the outlet of First Lake to Wolf Creek during the spawning period. This swim was the only method used to estimate the population of the summer stock.

The 2009 total estimate of 311 adult summer run Chinook was similar to the 1999-2008 average of 382 fish. The total jack population for the summer stock is estimated at 138 fish. No historical comparison can be made as no jack Chinook carcasses were recovered previous to 1995 (Hop Wo et al. 2006). It is important to note that this summer run estimate is a minimum run size, as it was determined from snorkel surveys and brood captures. It is possible that the actual run size may be significantly greater than the estimate provided. Ideally additional swims would have taken place, as with the fall run, and an AUC calculated for the summer stock.

SWIM SURVEYS

Swim surveys conducted in the lower portion of the Nanaimo River provided the primary information for generating a population estimate and spawning distribution of fall run Chinook. The last date, 19 October, used in AUC calculations, assumes that no more Chinook were available to be counted on or after this date. Any Chinook entering the system after this date would not be included in the AUC estimate. A tagging study in 2006 conducted to obtain the survey life statistic for fall run Nanaimo River Chinook, generated an estimate of 11.5 days.

The fall run jack Chinook estimate generated by AUC calculations utilized the same observer efficiency applied to adult Chinook, as no specific observer efficiency was available for jacks. As jack Chinook are physically smaller than most adults, jacks may be harder to see in the river and would therefore have lower observer efficiency, resulting in increased expansions to the estimates. Similarly, the survey life statistic of 11.5 days was intended for adult Chinook, and therefore assumes that adults and jacks are both available to be counted for the same amount of time.

FIRST NATIONS FOOD FISHERY

Following consultations between Snuneymuxw First Nation Guardians and DFO Stock Assessment staff, a method of calculating the in-river catch was developed. The actual calculation is similar to that used to derive catch estimates in the Strait of Georgia creel survey. The 2009 catch estimate for the SFN fishery has been determined as 449 adult Chinook and unknown jack catch. For the purpose of total river returns, this estimate will be added to the escapement. SFN catch estimates are difficult to compare year to year as methods for determining these results have not been consistent between years.

BIOLOGICAL DATA

Both mark-recapture samples and broodstock samples collected from fall run Chinook were expected to have negligible variation in lengths as they were retrieved from the same population. However, male and female fall run broodstock were found to be significantly smaller than the fish sampled on the spawning grounds. Jacks could not be statistically determined in any analysis as there were too few sampled. There was no significant difference between male or female summer run fish when comparing hatchery broodstock to fish sampled on the spawning grounds.

Due to very low jack recoveries for the summer run stock no statistical analysis was performed to compare summer run jacks.

Consistent with most years, female fall run Chinook were significantly larger than fall run males when comparing hatchery samples. This is partially due to the slightly older makeup of the female population, which contained some age 4 fish, whereas few age 4 fish were recovered from the male population. There was no significant difference between males and females of the summer run stock; however, females sampled on the spawning grounds were on average 84 mm larger than males sampled from the same location.

There was one female Chinook adipose-clipped CWT obtained during the hatchery broodstock collection. The CWT tag indicated the fish originated from the Chemainus River (2006 brood release). With fewer releases of fish containing CWT's over the last few brood years, comparing stray rates cannot be made. It is interesting to note that over the past four years, only strays from the Chemainus River have been detected. No statistical analyses on adipose-clipped Chinook were conducted due to insufficient number of recoveries.

WATER MANAGEMENT PLAN

Due to sufficient flows for most of the migration period, only one scheduled water release occurred on 5 October. As a result fish we observed that the Chinook had spread out over the spawning area. Other than the 5 October release, it was not necessary to implement additional water releases in 2009, as natural flows for October were above the target flows of 14.87 m^3/s outlined in the WMP.

POPULATION ESTIMATE

The 2009 Nanaimo River fall run Chinook population estimate was based on the AUC swim survey calculation that produced estimates of 1,470 adults and 630 jacks. One of the goals of this study was to have two independent and analytical methods of estimating the population of fall run Chinook. The carcass mark-recapture program was to provide data to calculate a Petersen estimate. The Petersen calculations could not be done because there were insufficient recovery data.

The natural spawning estimate of fall run adult Chinook (1,319) is approximately 7.67% higher than the 1995-2005 average of 1,225 fish. However, given that there have been several methods used to estimate the total return; it is difficult to make true comparisons. Annual fall run adult Chinook estimates by type (fence, Petersen mark-recapture, and AUC) are presented in Tables 11A, and 11B.

Chinook estimates are ideally obtained by periodic swim surveys. Only one summer run survey was completed during the 2009 spawning season, which occurred in a known spawning area. The summer run estimate was 148 adults which is 16.62% of the historical average. It should be noted that previous spawning escapement were estimated using multiple swims. Annual adult Chinook escapements are presented in Tables 11A, 11B, and Figure 5.

The total adult return for both summer and fall run Chinook including natural spawners, hatchery broodstock, and SFN FSC catch is 2,230 fish.

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TABLES

Table 1. Nanaimo River Daily Discharge[1] (m³/sec), 2009

Nanaimo River Daily Discharge

	Month											
Day	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	13.2	15	34.3	22.6	22	20	5.25	4.86	5.24	4.29	99.5	139
2	12.4	15.4	109	23.3	24.1	18.3	4.95	4.76	5.56	4.39	55.4	88.1
3	11.5	16.5	131	23	32.1	17.6	4.74	4.5	5.38	4.48	36.5	57.5
4	11.3	17	92	21.8	35.5	17.1	4.71	4.25	6.01	4.51	30.4	41.2
5	11.8	17.7	59.4	20.8	85	16.2	4.46	4.13	5.8	4.5	52.5	32.4
6	12.1	18.6	44	20.6	109	15.4	4.32	4.25	4.9	4.51	163	27.2
7	46.1	19.3	36	23.1	88.8	14.1	4.2	4.34	4.8	5.89	159	23.6
8	117	19.1	30.5	27.1	72.2	12.5	4.09	4.39	4.93	12	111	20
9	105	18.4	26.9	30.8	53.6	11.2	4.06	4.47	6.29	10.6	161	17.7
10	79.7	17.7	23.7	32.8	42.1	10.3	4.25	4.05	7.83	5.59	171	16.3
11	77.4	17.1	21.2	33.2	38.1	9.08	4.67	3.94	6.94	4.62	114	15.4
12	69	16.3	19.3	45.3	37.4	8.56	4.95	4.34	6.48	4.33	78.3	14.4
13	61.1	15.5	17.9	68.5	33.6	8.32	4.91	4.81	6.09	4.21	59.4	13.5
14	53.8	14.7	17.4	60	30.9	8.03	5.09	4.9	6.02	4.38	45.7	12.8
15	44.4	14	17.6	44.7	30.2	7.5	5.23	5.01	5.67	5.52	77.1	13.2
16	34.3	13.2	19.9	36.3	30	6.97	5.05	4.63	5.8	18.4	577	38.2
17	31.6	12.6	19.9	35.6	32.5	6.6	4.89	4.52	5.61	37.5	467	125
18	31.4	11.9	19.6	40.9	36.4	6.22	4.85	4.65	5.7	54.2	227	145
19	34.1	11.4	25.6	40	34.1	5.93	4.91	4.47	6.05	38.1	238	127
20	35.2	11	53.3	40.4	29.2	5.71	4.78	4.32	6.03	26.1	440	120
21	33.5	11	82.8	52.7	25.7	5.45	4.72	4.24	6.01	21.3	272	196
22	30.4	11.3	64.1	61.4	23.3	5.29	4.85	4.09	5.97	18.6	169	157
23	27.4	19.1	45.4	49.7	22.5	4.94	4.95	3.99	5.83	19.2	120	93.1
24	24.8	29.7	36.4	35.8	22.7	4.81	5	3.93	5.8	22	112	56.2
25	22.7	42.5	32	30.3	23.9	6.19	5.05	3.85	5.26	21	242	42.8
26	20.5	43.7	28.9	26.9	25.8	6.8	4.87	3.67	4.6	27.5	370	34.6
27	19.1	35.5	26.6	25.2	27.9	6.68	4.73	3.59	4.3	32.2	191	28.8
28	17.8	29.6	25.5	24.2	24.4	6.57	4.66	3.63	4.17	28.1	110	24.9
29	16.8		24.1	23.1	22.3	6.14	4.62	3.75	4.18	25.1	101	22.5
30	16.1		22.5	22.2	21.9	5.74	4.56	4.33	4.22	29.8	145	20.6
31	15.3		22.3		20.8		4.63	4.84		131		19.5
Total	1136.8	534.8	1229.1	1042.3	1158	284.23	147	133.5	167.47	633.92	5194.8	1783.5
Mean	36.7	19.1	39.6	34.7	37.4	9.47	4.74	4.31	5.58	20.4	173	57.5
Dam3	98200	46200	106000	90100	100000	24600	12700	11500	14500	54800	449000	154000
Max	117	43.7	131	68.5	109	20	5.25	5.01	7.83	131	577	196
Min	11.3	11	17.4	20.6	20.8	4.81	4.06	3.59	4.17	4.21	30.4	12.8

[1]Data recorded at Water Survey Canada Station 08HB034 which is located upstream of Cassidy,
B.C.
Discharge data are preliminary and

Table 2: Daily summary of fall run Chinook sampled during the carcass mark – recapture program, lower Nanaimo River, 2009

	Carcasses Examined				Tags Applied				Recapture Carcasses			
Date	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown
10/19/2009	6	6	2	0	6	6	2	0	0	0	0	0
10/20/2009	2	7	0	0	2	7	0	0	0	0	0	0
10/21/2009	3	7	2	0	2	7	2	0	1	0	0	0
10/26/2009	5	9	1	0	4	8	1	0	1	1	0	0
10/27/2009	7	7	1	0	7	6	1	0	0	1	0	0
10/29/2009	0	2	0	0	0	2	0	0	0	0	0	0
10/30/2009	3	7	0	0	1	6	0	0	2	1	0	0
Total	26	45	6	0	22	42	6	0	4	3	0	0

Table 3: Swim survey counts for adult Chinook with observer efficiency and system estimates, conducted on the lower Nanaimo River, 2009

		Chinook Counts				Estimated Chinook				In-River Chinook Estimate (L+D)	
Swim Date	OE%	Live Adult	Dead Adult	Live Jack	Dead Jack	Live Adult	Dead Adult	Live Jack	Dead Jack	Adults	Jacks
31/8/2009	90.00	143	0	31	0	159	0	34	0	159	34
8/9/2009	91.00	77	0	41	0	85	0	45	0	85	45
14/9/2009	90.00	189	0	108	0	210	0	120	0	210	120
22/9/2009	90.00	264	0	64	0	293	0	71	0	293	71
29/9/2009	90.00	175	0	107	0	194	0	119	0	194	119
6/10/2009	90.00	291	0	156	0	323	0	173	0	323	173
13/10/2009	90.00	448	0	199	0	498	0	221	0	498	221
19/10/2009	60.00	63	0	19	0	105	0	32	0	105	32

Table 4: 2009 Nanaimo River Hatchery broodstock collection summary for fall and summer run Chinook

Number of Fish	Fall Chinook			Summer Chinook		
	Female	Male	Jack	Female	Male	Jack
Captured	79	72	50	69	94	2
Spawned	79	54	25	59	64	0
Mort	0	18	15	1	1	0
Released	0	0	10	8	29	2
Kelt	0	0	0	0	0	0

Table 5A: Length-Frequency of fall run Chinook sampled during carcass mark-recapture, lower Nanaimo River, 2009

Length (cm)	Length (mm)	Males	Females	Jacks
23	230	0	0	0
24	240	0	0	0
25	250	0	0	0
26	260	0	0	0
27	270	0	0	0
28	280	0	0	0
29	290	0	0	0
30	300	0	0	0
31	310	0	0	0
32	320	0	0	0
33	330	0	0	0
34	340	0	0	0
35	350	0	0	0
36	360	0	0	0
37	370	0	0	0
38	380	0	0	**1**
39	390	0	0	**1**
40	400	0	0	**1**
41	410	0	0	0
42	420	0	0	0
43	430	0	0	**1**
44	440	0	0	**1**
45	450	0	0	**1**
46	460	0	0	0
47	470	0	0	0
48	480	**1**	0	0
49	490	**1**	0	0
50	500	0	0	0
51	510	0	0	0
52	520	0	0	0
53	530	0	0	0
54	540	**1**	0	0
55	550	0	0	0
56	560	**1**	0	0
57	570	**1**	0	0
58	580	**1**	**2**	0
59	590	**2**	**1**	0
60	600	**2**	0	0
61	610	**1**	**5**	0
62	620	**1**	**4**	0
63	630	0	**3**	0
64	640	**1**	0	0
65	650	**3**	**1**	0
66	660	**3**	**1**	0
67	670	**1**	0	0
68	680	0	**4**	0

69	690	**1**	0	0
70	700	0	**1**	0
71	710	**1**	**1**	0
72	720	0	0	0
73	730	0	**4**	0
74	740	0	**4**	0
75	750	0	**2**	0
76	760	0	**3**	0
77	770	0	**2**	0
78	780	0	**3**	0
79	790	0	**1**	0
80	800	0	0	0
81	810	0	0	0
82	820	0	0	0
83	830	0	0	0
84	840	0	0	0
85	850	0	0	0
86	860	0	0	0
87	870	0	0	0
88	880	0	0	0
Total		22	42	6
Mean Length		612	689	418
Standard Deviation		68.6.	67.3	28.8
Adipose Clips		0	0	0
Mark Rate		0	0	0

Table 5B: Length-frequency of summer run Chinook sampled during carcass mark-recapture, Upper Nanaimo River, 2009

Length (cm)	Length (mm)	Males	Females	Jacks
23	230	0	0	0
24	240	0	0	0
25	250	0	0	0
26	260	0	0	0
27	270	0	0	0
28	280	0	0	0
29	290	0	0	0
30	300	0	0	0
31	310	0	0	0
32	320	0	0	0
33	330	0	0	0
34	340	0	0	0
35	350	0	0	0
36	360	0	0	0
37	370	0	0	0
38	380	0	0	0
39	390	0	0	0
40	400	0	0	0
41	410	0	0	0
42	420	0	0	0
43	430	0	0	**1**
44	440	0	0	0
45	450	0	0	0
46	460	0	0	0
47	470	0	0	0
48	480	0	0	0
49	490	**1**	0	0
50	500	0	0	0
51	510	0	0	0
52	520	0	0	0
53	530	0	0	0
54	540	0	0	0
55	550	0	0	0
56	560	0	0	0
57	570	**1**	0	0
58	580	**1**	0	0
59	590	0	**1**	0
60	600	0	0	0
61	610	0	0	0
62	620	0	**1**	0
63	630	**1**	0	0
64	640	0	0	0
65	650	0	0	0
66	660	0	0	0
67	670	0	0	0
68	680	**1**	0	0

69	690	0	0	0
70	700	0	**1**	0
71	710	0	**1**	0
72	720	0	**1**	0
73	730	0	0	0
74	740	0	0	0
75	750	0	0	0
76	760	0	0	0
77	770	0	0	0
78	780	0	0	0
79	790	0	0	0
80	800	0	0	0
81	810	0	0	0
82	820	0	0	0
83	830	0	0	0
84	840	0	0	0
85	850	0	0	0
86	860	0	0	0
87	870	0	0	0
88	880	0	0	0
Total		5	5	1
Mean Length (mm)		590	668	0
Standard Deviation		71.1	58.9	0
Adipose Clips		0	0	0
Mark Rate (%)		0	0	0

Table 6A: Summary of age data from fall run Chinook sample during the carcass-mark recapture program, lower Nanaimo River 2009

Gilbert-Rich Age[1]	Brood Year	Total Age	Males		Females		Total	
			#	%	#	%	#	%
21	2007	2	1	7.1	1	3.4	2	4.7
31	2006	3	11	78.6	10	34.5	21	48.8
41	2005	4	2	14.3	18	62.1	20	46.5
Total			14	100	29	100	43	100

[1] The first number indicates the total age, the second number indicates the number of winters spent in freshwater.

Table 6B: Summary of age data from summer run Chinook sample during the carcass-mark recapture program, upper Nanaimo River 2009

Gilbert-Rich Age[1]	Brood Year	Total Age	Males		Females		Total	
			#	%	#	%	#	%
21	2007	2	0	0	0	0	0	0
31	2006	3	5	100	3	100	8	100
41	2005	4	0	0	0	0	0	0
Total			5	100	3	100	8	100

[1] The first number indicates the total age, the second number indicates the number of winters spent in freshwater.

Table 7: Length-frequency of fall run Chinook sampled from hatchery broodstock, lower Nanaimo River, 2009

Length (mm)	Males	Females	Jacks
280	0	0	0
290	0	0	0
300	0	0	0
310	0	0	0
320	0	0	0
330	0	0	0
340	0	0	0
350	0	0	0
360	0	0	**1**
370	0	0	**1**
380	**1**	0	**2**
390	**1**	0	**2**
400	**1**	0	**3**
410	**1**	0	0
420	0	0	**3**
430	**1**	0	**4**
440	**2**	0	**3**
450	0	0	**5**
460	**1**	0	0
470	**3**	0	0
480	**3**	0	**1**
490	**1**	0	0
500	**2**	0	0
510	**4**	0	0
520	**2**	0	0
530	**2**	**1**	0
540	**1**	**1**	0
550	0	**1**	0
560	**3**	**1**	0
570	**2**	**5**	0
580	**6**	**3**	0
590	**2**	**3**	0
600	**2**	**2**	0
610	**2**	**1**	0
620	**2**	**6**	0
630	**1**	**7**	0
640	**4**	**6**	0
650	**2**	**2**	0
660	**4**	**4**	0
670	0	**4**	0
680	**1**	**2**	0
690	0	**2**	0
700	0	**3**	0
710	0	**1**	0
720	0	0	0
730	0	**3**	0
740	0	**3**	0

750	0	0	0
760	0	**2**	0
770	**1**	**1**	0
780	0	**1**	0
790	0	**1**	0
800	0	**1**	0
810	0	0	0
820	0	0	0
830	0	0	0
Total	58	67	25
Mean Length (mm)	553	650	420
Standard Deviation	119.9	98.9	46.1
Adipose Clips	0	0	0
Mark Rate (%)	0	0	0

Table 8A: Summary of age data from fall run Chinook broodstock collection, lower Nanaimo River, 2009

Gilbert Rich Age [1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
2_1	2007	2	9	25.7%	0	0.0%	9	17.6%
3_1	2006	3	23	65.7%	7	43.8%	30	58.8%
4_1	2005	4	3	8.6%	9	56.3%	12	23.5%
Total			35	100%	16	100%	51	100%

[1] The first number indicates the total age, the second number indicates the number of winters spent in freshwater

Table 8B: Summary of age data from First Lake summer run Chinook broodstock collection, upper Nanaimo River, 2009

Gilbert Rich Age [1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
2_1	2007	2	2	13.3%	1	8.3%	3	11.1%
3_1	2006	3	12	80.0%	9	75.0%	21	77.8%
4_1	2005	4	1	6.7%	2	16.7%	3	11.1%
Total			15	100%	12	100%	27	100%

[1] The first number indicates the total age, the second number indicates the number of winters spent in freshwater

Table 9: Nanaimo River Hatchery Chinook release data for brood years 1997 - 2007

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site	Run Type
183220	1997	25,240	70,000	36.06	6.67	7/5/1998	7/5/1998	First Lake	Summer
183221	1997	25,173	99,098	25.4	6	15/5/1998	15/5/1998	First Lake	Summer
183223	1997	28,252	43,881	64.38	6.01	26/5/1998	26/5/1998	Nanaimo R.	Fall
182408	1997	10,050	15,610	64.38	6.01	26/5/1998	26/5/1998	Nanaimo R.	Fall
183222	1997	24,824	24,824	100	15.5	23/7/1998	23/7/1998	Jack Point	Fall
-	1998	0	442,830	0	5.1	12/5/1999	13/5/1999	Nanaimo R.	Fall
-	1998	0	165,595	0	5.61	28/5/1999	28/5/1999	First Lake	Summer
-	1998	0	50,411	0	11	2/6/1999	8/7/1999	Jack Point	Fall
184330	1999	25,185	257,394	9.78	4.03	17/5/2000	17/5/2000	First Lake	Summer
184332	1999	25,071	25,071	100	5.1	18/5/2000	18/5/2000	Nanaimo R.	Fall
184331	1999	25,185	25,185	100	5.1	18/5/2000	18/5/2000	Nanaimo R.	Fall
184333	1999	25,165	25,165	100	5.1	18/5/2000	18/5/2000	Nanaimo R.	Fall
184334	1999	25,231	25,231	100	5.1	18/5/2000	18/5/2000	Nanaimo R.	Fall
-	1999	0	99,238	0	4.8	18/5/2000	18/5/2000	Nanaimo R.	Fall
184335	1999	25,300	126,422	20.01	5	5/5/2000	23/5/2000	Nanaimo R.	Fall
184336	1999	25,115	125,497	20.01	5	5/5/2000	23/5/2000	Nanaimo R.	Fall
184329	1999	25,175	57,625	43.69	10.34	23/6/2000	23/6/2000	Jack Point	Fall
184363	2000	24,739	207,955	11.9	6.56	23/5/2001	24/5/2001	First Lake	Summer
184552	2000	50,060	105,512	47.44	4.9	28/4/2001	29/5/2001	Nanaimo R.	Fall
184554	2000	50,259	105,931	47.45	4.9	28/4/2001	29/5/2001	Nanaimo R.	Fall
184553	2000	50,254	105,920	47.45	4.9	28/4/2001	29/5/2001	Nanaimo R.	Fall
184362	2000	25,091	51,070	49.13	8.67	6/6/2001	6/6/2001	Jack Point	Fall
184717	2001	25,119	102,917	24.41	4.68	9/5/2002	9/5/2002	Nanaimo R.	Fall
184718	2001	25,355	103,883	24.41	4.68	9/5/2002	9/5/2002	Nanaimo R.	Fall
183205	2001	25,182	25,182	100	5.61	14/5/2002	14/5/2002	Nanaimo R.	Fall
183206	2001	25,237	25,237	100	5.61	14/5/2002	14/5/2002	Nanaimo R.	Fall
184337	2001	25,102	186,187	13.48	5.7	16/5/2002	16/5/2002	First Lake	Summer
184715	2001	25,307	25,307	100	3.78	16/5/2002	16/5/2002	Nanaimo R.	Fall
184716	2001	25,131	25,131	100	3.78	16/5/2002	16/5/2002	Nanaimo R.	Fall
184628	2001	25,119	51,508	48.77	6.62	17/5/2002	17/5/2002	Jack Point	Fall
185527	2002	39,650	39,650	100	20	31/7/2003	31/7/2003	Nanaimo R.	Fall
185528	2002	40,226	40,226	100	10	31/5/2003	31/5/2003	Nanaimo R.	Fall
-	2002	0	173,081	0	7.17	6/5/2003	19/5/2003	First Lake	Summer
-	2002	0	324,204	0	6	8/5/2003	21/5/2003	Nanaimo R.	Fall
-	2003	0	187,214	0	6.93	18/5/2004	18/5/2004	First Lake	Summer
-	2003	0	120,199	0	4.86	19/5/2004	19/5/2004	Nanaimo R.	Fall
185713	2004	29,538	38,922	75.89	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
185714	2004	29,559	39,146	75.51	5.0	16/5/2005	15/6/2005	Nanaimo R.	Fall
185715	2004	29,392	38,729	75.89	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
185716	2004	29,293	38,792	75.51	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
185717	2004	29,124	38,763	75.13	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
185802	2004	27,774	36,782	75.51	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
185803	2004	24,568	32,535	75.51	5.0	19/5/2005	15/6/2005	Nanaimo R.	Fall
-	2004	0	154,922	0	8.0	18/5/2005	19/5/2005	First Lake	Summer

Table 9 (continued).

Tag code	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site	Run Type
-	2005	0	174,584	0	5.1	5/22/2006	5/23/2006	Nanaimo R.	Fall
-	2005	0	978	0	2.6	5/23/2006	5/23/2006	Nanaimo R.	Fall
-	2005	0	167,936	0	4.5	5/24/2006	5/24/2006	Nanaimo R.	Fall
-	2005	0	2000	0	3	5/24/2006	5/24/2006	Nanaimo R.	Fall
-	2006	0	421,467	0	--	5/23/2007	5/29/2007	Nanaimo R	Fall
-	2006	0	223,745	0	-	5/17/2007	5/17/2007	First Lake	Summer
-	2007	0	134,552	0	5.1	5/16/2008	5/16/2008	Nanaimo R.	Fall
-	2007	0	229,551	0	5.1	5/16/2008	5/16/2008	First Lake	Summer

Table 10: Chemainus River and Cowichan River Chinook release data for brood years 2002-2009

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site	Run Type
185129	2002	25,191	55,331	45.53	10	2003/05/15	2003/05/16	Chemainus R	Fall
185130	2002	25,253	55,394	45.59	10	2003/05/15	2003/05/16	Chemainus R	Fall
185131	2002	25,167	40,850	61.61	7	2003/05/15	2003/05/16	Chemainus R	Fall
185132	2002	25,282	40,966	61.71	7	2003/05/15	2003/05/16	Chemainus R	Fall
185530	2003	49,960	79,417	62.91	11.4	2004/05/07	2004/05/17	Chemainus R	Fall
185531	2003	50,283	79,775	63.03	5.44	2004/05/17	2004/05/18	Chemainus R	Fall
-	2004	0	22,164	0.00	9.5	2005/05/17	2005/05/17	Chemainus R	Fall
-	2005	0	25,807	0.00	9.96	2006/05/15	2006/05/15	Chemainus R	Fall
-	2005	0	23,519	0.00	9.58	2006/05/15	2006/05/15	Chemainus R	Fall
-	2005	0	26,934	0.00	9.97	2006/05/15	2006/05/15	Chemainus R	Fall
-	2006	0	158,668	0.00	-	2007/05/16	2007/05/16	Chemainus R	Fall
-	2007	0	22,818	0.00	10.8	2008/05/15	2008/05/15	Chemainus R	Fall
184918	2002	50,091	383,156	13.07	4.5	2003/04/11	2003/04/11	Cowichan R Upper	Fall
184919	2002	50,186	383,877	13.07	4.5	2003/04/11	2003/04/11	Cowichan R Upper	Fall
185013	2002	24,712	257,226	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Upper	Fall
185014	2002	25,128	261,555	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Upper	Fall
185015	2002	25,102	261,282	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Upper	Fall
185016	2002	25,197	288,668	8.73	6	2003/05/27	2003/05/27	Cowichan R Lower	Fall
185052	2002	25,134	99,918	25.15	7.36	2003/05/28	2003/05/28	Cowichan Bay	Fall
185412	2003	25,144	99,887	25.17	6.54	2004/05/26	2004/05/26	Cowichan Bay	Fall
185660	2003	25,111	197,202	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Upper	Fall
185661	2003	25,110	197,194	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Upper	Fall
185662	2003	25,124	197,304	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Upper	Fall
185663	2003	25,051	196,731	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Upper	Fall
185701	2003	25,168	219,733	11.45	5.3	2004/05/20	2004/05/20	Cowichan R Upper	Fall
185702	2003	24,863	219,261	11.34	5.3	2004/05/20	2004/05/20	Cowichan R Upper	Fall
185703	2003	24,987	219,252	11.40	5.3	2004/05/20	2004/05/20	Cowichan R Upper	Fall
185704	2003	25,029	98,411	25.43	6.65	2004/05/11	2004/05/11	Cowichan R Lower	Fall
-	2003	0	116,307	0.00	2.41	2004/11/08	2004/11/19	Cowichan L Tributaries	Fall
185261	2006	27,813	39,288	0.00	4.6	2007/05/15	2007/05/15	Chemainus R	Fall

Table 11A: Total adult Chinook returns to the Nanaimo River, 1975-2009

	Natural Spawners		Hatchery Broodstock		First Nations	Total Returns
Year	Fall	Summer	Fall	Summer	Food Fish Catch	
1975	475	-	-	-	15	490
1976	880	-	-	-	50	930
1977	2380	-	-	-	60	2420
1978	2125	-	-	-	40	2165
1979	2700	-	41	-	23	2764
1980	2900	-	82	-	200	3182
1981	210	-	15	-	100	325
1982	1090	-	62	-	21	1173
1983	1600	-	240	-	30	1870
1984	3000	-	178	-	50	3228
1985	650	-	264	-	185	1099
1986	700	-	258	-	190	1148
1987	400	-	357	-	50	807
1988	650	-	429	-	0	1079
1989	1150	-	402	-	0	1552
1990	1275	-	122	-	0	1397
1991	800	-	135	-	0	935
1992	800	-	377	-	0	1177
1993	850	-	528	-	0	1378
1994	400	-	280	-	10	752
1995	1592 [2]	100	311	75	50	2128 [3]
1996	990 [2]	600	257	167	335	2349 [3]
1997	638 [2]	600	52	129	0	1419 [3]
1998	1011 [2]	200	251	89	0	1551 [3]
1999	1920 [4]	500	242	179	70	2911 [3]
2000	596 [6]	450	184	162	126	1518 [3]
2001	1277 [6]	250	165	169	188	2049 [3]
2002	946 [6]	432	212	205	213	2008 [3]
2003	1378 [7]	393	82 [8]	131 [8]	50	2034 [3]
2004	1891 [9]	200	119 [10]	106	220	2549 [11]
2005	1239 [9]	201	186	122	950	2705 [11]
2006	1723 [9]	672	220	168	580	3363 [11]
2007	2222 [9]	220 [9]	100	126	225	2893 [11]
2008	2281	506	200	189	720	3896 [11]
2009	1319[9]	148	151	163	449	2230[11]

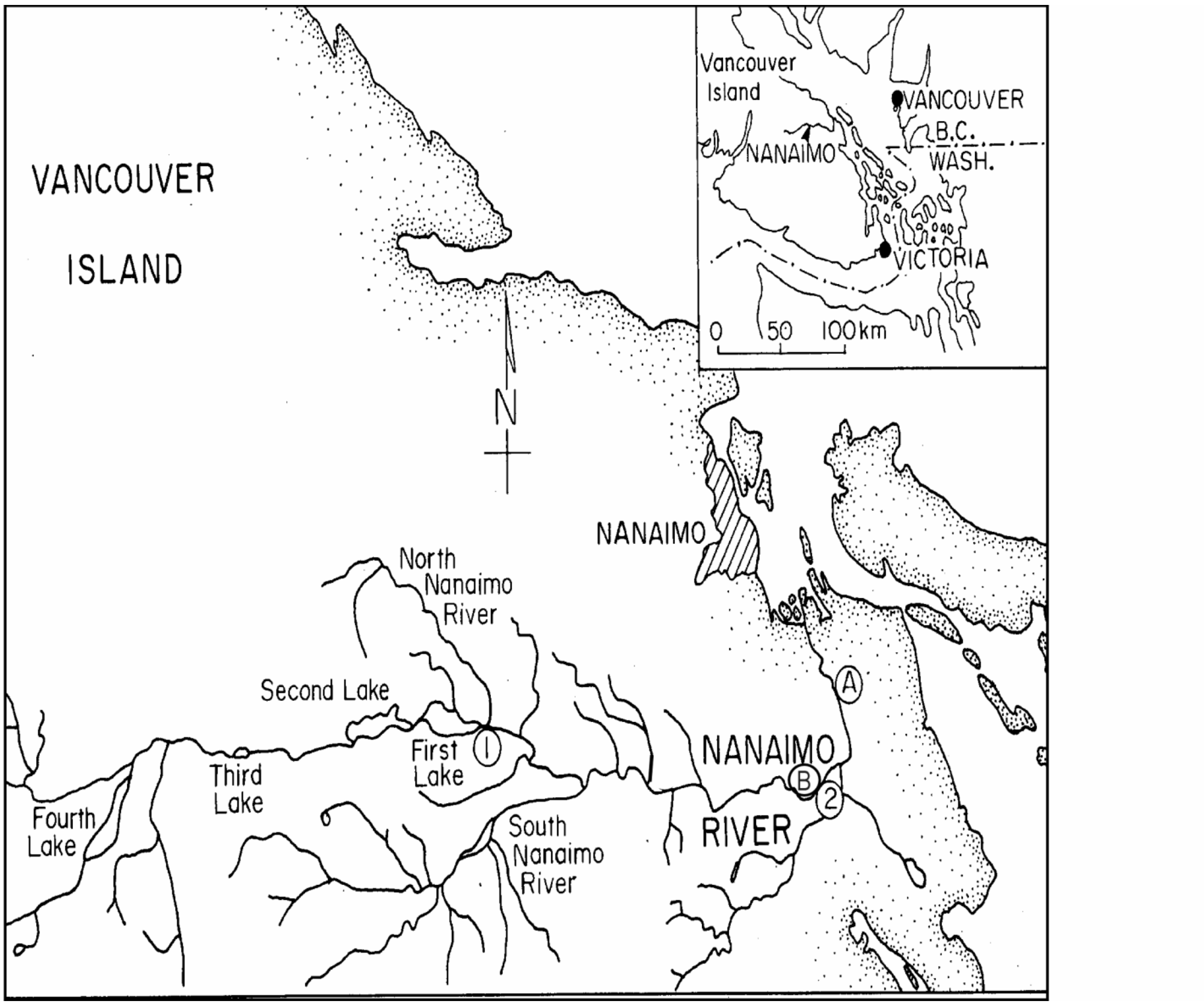
[1] Ocean type only
[2] Count at enumeration fence minus broodstock removal above the fence.
[3] Fall natural spawners plus fall broodstock removal below the fence, Native food fish catch and summer run estimate.
[4] Mark recapture Petersen estimate.
[5] Mark recapture estimate plus fall broodstock removal, Native food fish catch and spring run estimate.
[6] Adjusted fence count minus broodstock removal above the fence.
[7] Extrapolated fence count, plus adult/jack adjustment, minus broodstock removals above the fence.
[8] Does not include fish release during high water
[9] AUC estimate minus broodstock removal
[10] 107 fish from Nanaimo River Mainstream and 12 from Napoleon Creek
[11] AUC estimate plus summer run estimate, broodstock removals, Native food fish catch

Table 11B: Total jack Chinook returns to the Nanaimo River, 1995 - 2009

	Natural Spawners		Hatchery Broodstock		First Nations	Total
Year	Fall [1]	Summer [2]	Fall	Summer[1]	Food Fish Catch	Returns [3]
1995	3236	200	88	N/A	-	3524
1996	891	-	72	28	-	991
1997	173	-	24	12	-	209
1998	599	-	30	6	-	635
1999	280 [4]	-	3	21	-	304 [5]
2000	992	-	10	6	-	1008
2001	1385 [6]	-	19	27	-	1431
2002	644 [6]	-	15	15	-	674
2003	772 [7]	-	48	8	-	828
2004	190 [8]	-	30	17	-	255
2005	487 [8]	16	58	91	-	654
2006	2716 [8]	120 [9]	66	8	-	2910
2007	1931 [8]	12	44	12	62	2061
2008	843 [8]	133	52	5	-	1033
2009	580 [8]	36	50	2	-	668

[1] Count at enumeration fence minus broodstock removal above the fence.
[2] First Lake summer run only.
[3] Natural spawners plus fall broodstock removal below the fence, Native food fish catch and summer run estimate.
[4] Mark recapture Petersen estimate.
[5] Mark recapture estimate plus fall broodstock removal, Native food fish catch and spring run estimate.
[6] Adjusted fence count minus broodstock removal above the fence.
[7] Extrapolated fence count, plus adult/jack adjustment, minus broodstock removals above the fence.
[8] AUC estimate minus broodstock removals.
[9] Swim Survey Estimate

FIGURES



LEGEND:

1 Hatchery Release Site
2 Hatchery Release Site
A Enumeration Fence Site (removed 2003)
B Downstream Fry Trapping Site

Figure 1. Nanaimo River study area.

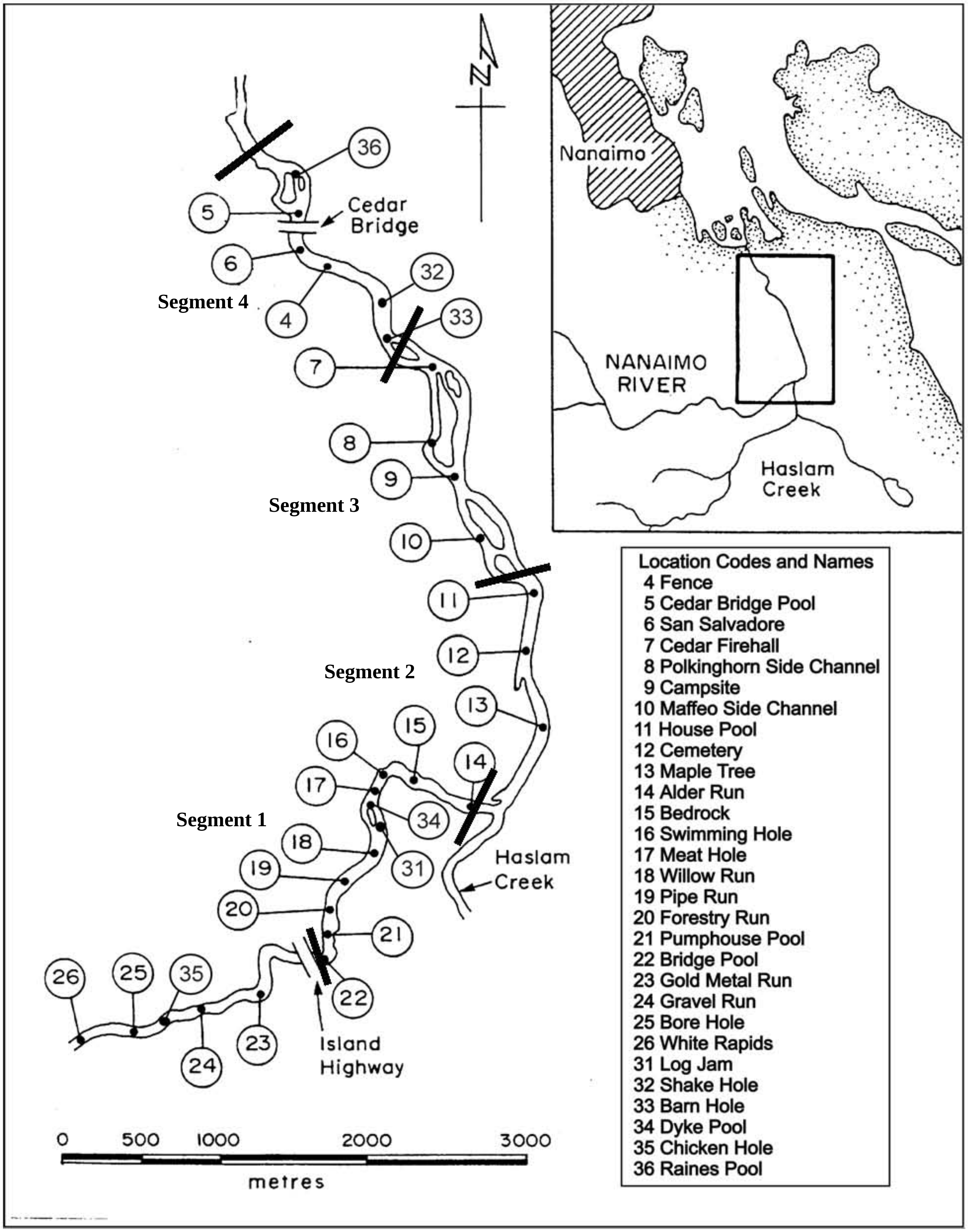


Figure 2. Swim survey and mark-recapture sites on the lower Nanaimo River.

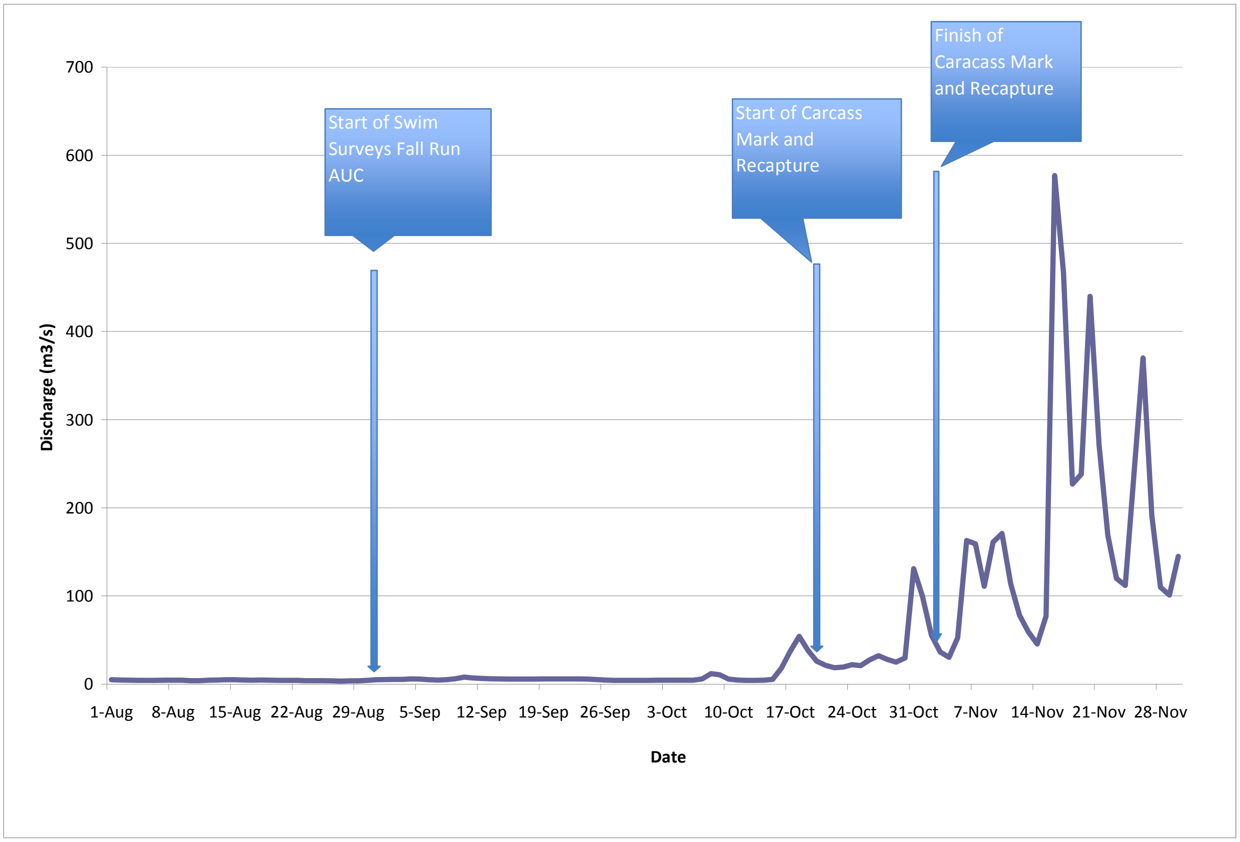


Figure 3. Daily Nanaimo River Discharge (m^3/s) during the fall run Chinook season 2008. Discharge data are preliminary and subject to revision.

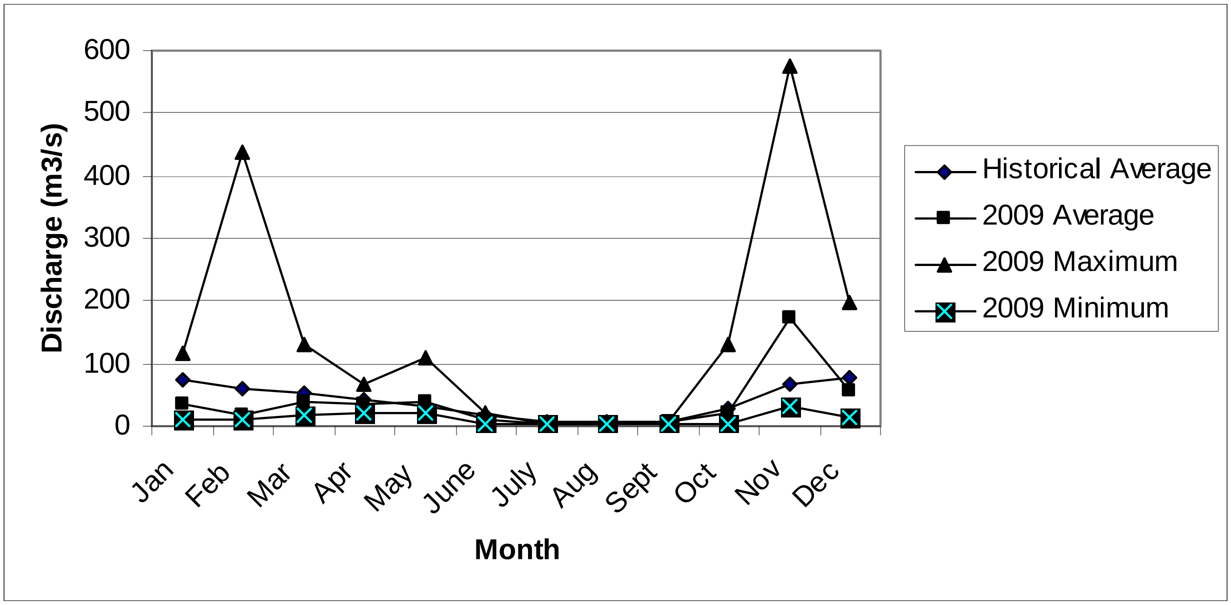


Figure 4. Monthly Nanaimo River discharge (m^3/s) in 200 along with historic (1965-2009) monthly mean.

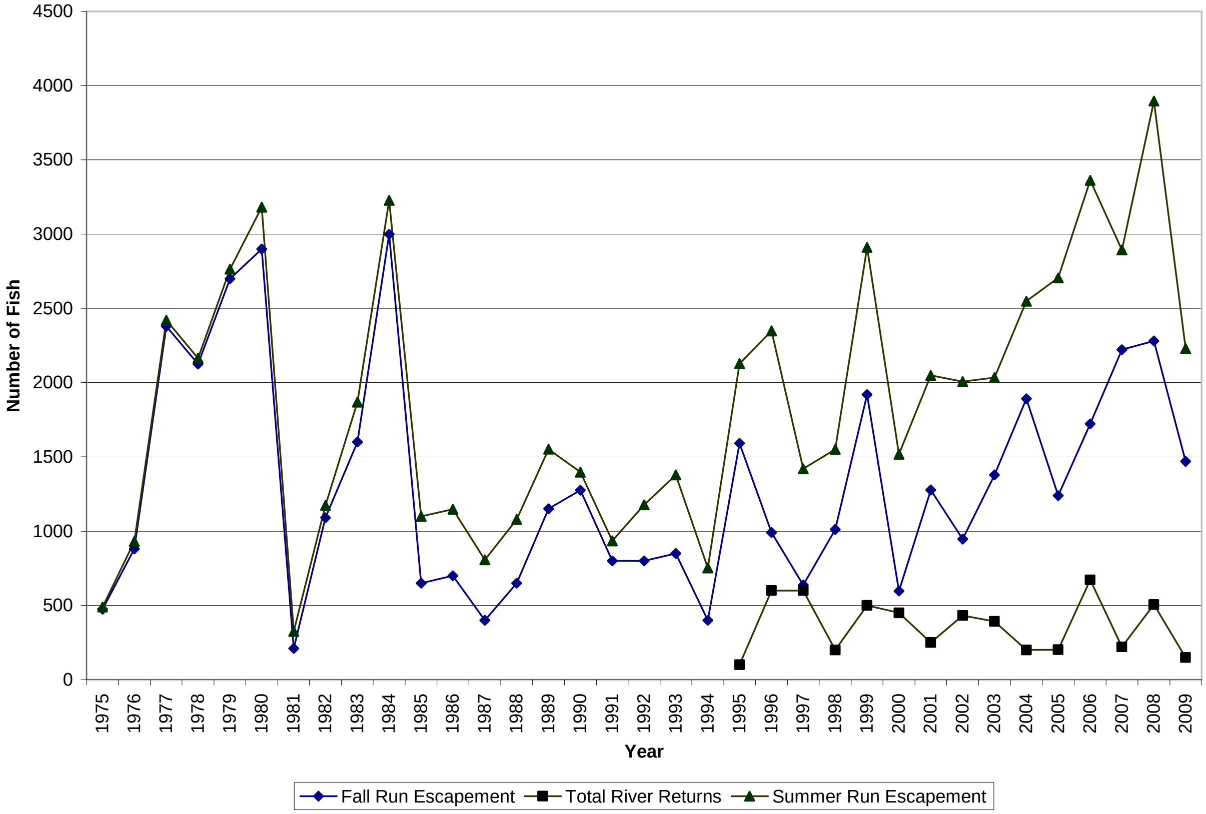


Figure 5. Annual Adult fall and summer run Chinook escapements in the Nanaimo River 1975-2009